Frontiers of Architectural Research (2013) 2, 373–376

HIGHER EDUCATION PRESS
Available online at www.sciencedirect.com
ScienceDirect
www.elsevier.com/locate/foar
Frontiers of Architectural Research

COLUMN

The university graduate training for the future engineering as exemplified by VEC-BEN collaboration (12 institutes from 4 continents)

Mark Bomberg*, Faras Tse

McMaster University, Hamilton L8S 4L8, Canada

Contents

1. Introduction

The first problem with “internationalising” the graduate study in developing countries is the lack of foreign language skills of the students. The first author is currently teaching on three universities with different level of English speaking: (1) English is the mother tongue of most students, (2) most students understand English though they cannot speak it, and (3) most students understand only some English. Similarly to the language skills, exposure to foreign technology varies from some foreign technology to none. The second author of this article is a Chinese-Canadian who experienced different cultures as a student. So with this combined background we will attempt to address the issues of training graduate students for the future of construction.

To set the benchmark in technology, the first author once wrote a paper for a conference in the language of the country in which the conference took place and presented it in English. The paper presented expansion of building physics from its first attempt to improve indoor climate in buildings (80 years ago) to today's position as the key to design durable, energy efficient buildings that are adapted to the regional climate and that provide excellent indoor environment. The paper highlighted the need for equilibrium between the social and economic issues on one side and the ecological (green) considerations on the other side but all in concert with the socio-economic and cultural position of the country in which the construction takes place. The latter comment is particularly important for the developing countries, which often try to transplant the foreign technology “as is”.

2. Objectives in training for the future engineering

Sometimes we say that students of today are trained for the needs of the previous generations but we seldom try to

*Corresponding author.
E-mail address: mark.bomberg@gmail.com (M. Bomberg).

Peer review under responsibility of Southeast University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.foar.2013.07.002

define what are the needs of the next generation. For the sake of discussion, we will define it as follows:

(1) Learning of the self-learning process in which on the technical side one can identify:
  (a) The socio-economic needs of the society and evaluate the fit between them and the discussed technology.
  (b) The constrains and barriers to implementation of the emerging technology.
  (c) The strength and weakness of critical elements of the technology and work on improvement of the selected weaknesses.
(2) Learning of the self-learning process in which on the business side one can identify:
  (a) Impediments of the cultural differences on the solutions acceptable under point (1a).
  (b) Effects of the financial constrains on the technical solutions acceptable under point (1a).
(3) Learning of the applications of the problem solving technics to be able to overcome the impediments listed under point (2).

These three points can be summarized as mastering of the self-learning process for analyzing the interaction between any specific technology and society and the capability to improve any emerging technology from cost-benefit point of view. Translating it to the teaching of building physics it means that we will focus on the principles of design and performance and their applications from point of view of the design and construction process *and as they are today presented in the market place*. This may be a simple switch for the experienced teacher but from the student point of view it means a complete revolution of what one learns and why. To complicate it further, we will deal with the process of learning of the building physics in a foreign language.

3. Improving the model of teaching in a foreign language

Traditional teaching of the building physics for a European graduate student is based on highly focused technical information with a lot of equations and use of precise technical terms. This is a not very suitable approach for a multi-disciplinary education in a foreign language, particularly when many graduate students come from the "soft" engineering faculties such as Architecture, or technical disciplines much different from construction. An American model of interactive education is much closer to satisfy the teaching objectives but in many countries such as Poland or China, the students are not accustomed to any interaction with a teacher and this model does not work (I tried to no avail).

Years ago, when I was teaching in Montreal, where for the most of the students English was either a second or a third language—developed a hybrid model. The written document contained all necessary equations and the precise language, but in the classroom only some equations were used. Others were replaced by the relationships of the discussed parameters. Typically only two or three more advanced students used to respond to my questions and all other students were allowed sit as passive listeners. One of the active students was taking the role of TA (teaching or translation assistant). Typically it was a Chinese student with good English skills (incidentally now all my TA from this time are research leaders in the US and Canada). The real job of the TA was to carry an official rehersal of the lecture in Chinese. Every week, there was a 50% of the lecture time allotted for the TA to summarize the key points of the last lecture and answer all the questions from students in their native language. Those questions that TA could not answer were passed to me to answer in the next lecture.

Nevertheless, when I started teaching in China it became evident that teaching in a foreign country is not the same as having foreign students in your own country. The TA there was either a young professor was engaged in developing of his course with no interest in my course or two students who tried as hard as they could but hardly qualified as interpretors. Finally, the problem was resolved by hiring a language student to support the translation by the TA student.

Now, the issue of introducing the interactive mode of learning remains to be solved. To this end, at Tongji University (where only 10% of the best students are admitted) the students declared that they do not need any translation of the lectures. We have instituted 3-h long modules but the first hour the teaching is given by 3 students. Of course, the students are given the course material before the course, and starting from the second lecture three of them are to give one 10–15 min long lecture each on the same topic as scheduled for the lecture. Three other students (scheduled for the next lecture) and I are providing comments on the student's presentations. After a short break I proceed with the standard 2 h long lecture on the topic of the day. The effect is that all written exams from this course are good or very good. At the other Chinese Universities, I require only power point slides to be prepared in English and the student can present the lecture in Chinese assisted with a professional interpretation[1].

4. Including the future technology in the current course

In the year 2010 the Southeast University jointly with Building Physics Society of China organized a national conference in which several invited speakers from the West participated. Two of us postulated that in a mixed climate such as Nanjing or Shanghai one needs to design building enclosures with switchable mass and switchable thermal insulation (see Bomberg, 2010). The follow up of this conference took place during the APEC 2013 conference in Hunan, China by creating a network ***virtual environmental control: buildings and energy network*** (VEC–BEN). This network intends to highlight the principles used in development of two parallel projects, one in the USA and the other in China. Several other groups from Poland, France and Brazil joined this multi-disciplinary effort to develop a

[1]Currently the Research Assistant in the VEC–BEN is also to perform the role of the translator.

next generation of integrated technology suitable for net zero energy buildings in different climatic zones.

In this collaboration, each university supports own research program. Yet, the synergy makes this program more effective by the following elements: (1) planning of the new research, (2) interim progress report review by peers, (3) parallel work in different socio-economic and climate conditions and (4) joint development of public domain computer codes. To this end, we plan to hold two yearly seminar/workshops open to all VEC–BEN participants, in China during the spring term and in North America during the fall term.

The network comprises full members and associated members. While both categories are fully incorporated in the academic research and the students of each member Universities are interacting with the industry, the associated members play a specific supporting role in one aspect of the program One of the important functions of this network is to ensure that the involved students acquire both the academic and practical experience and developing a new technology.

This network is not a consortium, where projects are planned by a steering committee and its execution is supervised. This is a virtual network and that means each project is performed individually and the linkage with the other projects is achieved partly through the external coordination but mainly through the communication of the progress in work. To this end we will use two means of communication:

(1) Periodic communication/meetings of project leaders (these meetings are closed to the public).
(2) Seminar workshops on the selected topics (these are open to anyone wanting to attend).

Undertaking this network collaboration we hope to create the core of a new, environment friendly, technology for climate adapted building enclosures. In doing so one must consider both academic and industrial developments. Yet, since the proprietary nature industry do not mix well with the academic freedom of information, we ultimately have three separate groups:

(1) Building as a system (VEC–BEN core activities).
(2) Hygrothermal (HT) modeling linked with Energy Code as the selected public domain code.
(3) A few private sector companies collaborating with VEC–BEN. Group 3 is not discussed here.

The objective of VEC–BEN is to develop a universal, panelized and climate adjusted assemblies (systems) that are:

- **Smart** (adjusting the interior climate to the needs of the outside weather);
- **healthy** (to avoid VOC, and other pollutant emissions);
- **environment friendly**, **and affordable** (to conform to the society values);
- **durable** (to free up time and money spent on maintenance), as well as
- **become a net producer of energy**.

The following applications are considered:

(1) Exterior thermal upgrade for existing buildings of any type.
(2) Interior upgrade for improvement of indoor climate in concrete buildings.
(3) Panels for new construction from 1 to 30 stories high where building enclosure (BE) is integrated with HVAC and has switchable thermal insulation and thermal mass.

To this end, the consideration is given to:

(1) Either climatic plaster (a new patented type of hybrid between 3-coat stucco and EIFS lamina) or a structural glass functioning as a rain screen.
(2) Ventilated air cavity between two layers of thermal insulation.
(3) Fire protective composite layer is integrated with moisture buffer.
(4) Spray polyurethane foam (European fire class A2 or equivalent) is applied behind the exterior fire protective composite.
(5) Use of moisture as a phase changing agent (PCM).
(6) Use of encapsulated PCM either with laminar basalt fiber insulation or with a moisture buffer system.
(7) Use of solar thermal and PV integrated with the wall systems (if used).

To address both the building enclosure and HVAC considerations, the following graduate student projects are currently carried out:

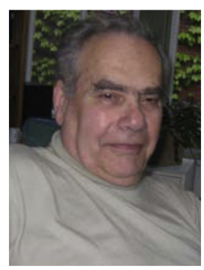
(1) Low energy panels involving phase change materials and ventilated air gap. This master thesis was initiated as an introduction to the next two PhD theses.
(2) Develop and evaluate performance of panelized system involving moisture buffer, phase change materials and solar utilization technologies. This is continuation and expansion of the previous theses.
(3) Performing architecture as means understanding and ensuring performance of materials, assembly and systems. This PhD thesis includes application of the proposed performance matrix.
(4) Energy management, from design to the monitoring of completed building. This project also includes comparison between predicted and measured energy usage.
(5) Comparison of different methods of PCM encapsulation in construction materials.
(6) Integration of heat, air and moisture transfer through the wall with that of the whole building with particular focus on moisture exchange in ventilated cavities. As part of this thesis a 2-D hygrothermal code will be written expanding from the existing codes. Verification of the models for moisture exchange to the moving air is also included in this PhD thesis.
(7) Combined application of solar thermal and photovoltaic on walls with structural glass finish. The student will also collaborate with project (10).

(8) Material characterization with a view to their hygrothermal performance. The review of material characterization issues with view to precise calculations of hysteretic behavior under cycling wetting and drying. This PhD thesis includes a specific application to development of climatic plaster with moisture buffering capability for improving indoor environment in concrete buildings.
(9) Build hygrothermal equipment and develop test procedures including the test error examination. This project also includes a double, self-calibrating Heat Flow Meter apparatus for study thermal characteristics of dry and of moist materials.
(10) Solar energy related heat transfer in walls. The work examines contribution of solar energy that can easily be captured by a few pipes as well as possibility of using the same devices for heating and cooling depending on the needs. This work will be linked with project (11).
(11) Night pre-cooling of the building enclosure in the integrated system when cooling is needed in the day. One will evaluate feasibility of placing hydronic heating or cooling plates in the middle of the highly insulated exterior wall with a view of lesser effect on heat gain but larger effect on wall cooling.
(12) Run style of ground source heat pump. The better understanding of ground source heat pump will assist us in the project on use two water tanks placed on each floor level and serving simultaneously 4–6 dwellings.
(13) Performance research on waste water re-use for showers with water-to-water heat pump. This is the second thesis on water to water heat pump that will throw light on water to water HP integrated with solar preheat for hydronic floor/ceiling or wall systems. In the future we will include evaluation of the DOAS combined with the de-humidification and stratified ventilation, integrated with the hot or cold tanks in project (10).
(14) Development of climatic plaster with moisture buffering capability for both exterior and interior applications.
(15) Comparison of different methods for measuring water vapor transmission as a function of RH.
(16) Combination of building insulation and moisture buffering material, in case of condensation and enzymes growth in wall.
(17) Project: Living Wall Materials and Systems for Automatic Building Thermo-Regulation.

The project at CU (USA) is focused on developing innovative passive wall elements and systems that can distribute the heat transfer through the wall to the entire building and thus fulfill the zero-energy need for building cooling and heating. This project involves 5 PhD students and 3 MS students from Architecture, Arch Engineering, Aerospace Engineering, Mechanical Engineering etc. Both modeling and experiment approach are used.

5. Closure

The rapid pace of developments in the field of sustainable buildings forced the leading Universities of North and South America, Europe and China to consider new methods of acceleration the pace of research and training the advanced students. It has been recognized that two way collaboration with other Universities and with the industry on development new technology benefits all parties involved and that the students sharing their time between the challenging environment of both the academic and practical worlds are better trained than those working in the academic world alone.



Mark Bomberg is the Doctor of Science (Engineering) at Warsaw University, Poland and Technology Doctor at Lund University, Sweden, coordinator of VEC–BEN, Professor at the faculty (1) Civil Engineering, McMaster University, Hamilton, Ontario, Canada; (2) Mechanical Engineering, Tongji University, Shanghai, China, (3) Architecture, Southeast University, Nanjing, China; Coordinator of System Integration, Building Enclosure Technology and Environment Council, National Institute of Building Science, Washington, DC, USA, editor J. Building Physics, London, UK.

Faras Tse is the PhD candidate, who applied for Natural Science and Engineering Research Council scholarship to work at McMaster University in Canada as the Research Assistant of VEC–BEN under supervision of Profs. Samir Chidiac and Mark Bomberg.